UMassAmherst | College of Engineering
Mechanical and Industrial Engineering

Yearlong Senior Capstone Design

1411 | Guide Dog Robot

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Objective

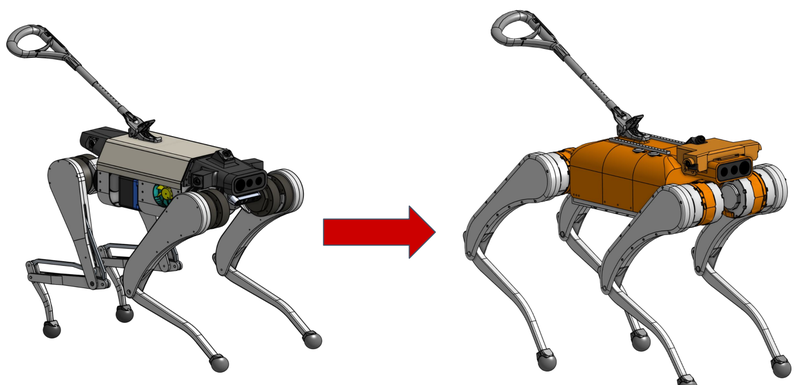
Design and fabricate the body and legs of a lightweight guide dog robot prototype capable of stair climbing while ensuring a compact body for portability and user-friendliness.

Motivation

Guide Dogs
- Training: $40,000
- Maintenance: $1000/year
- Limited availability

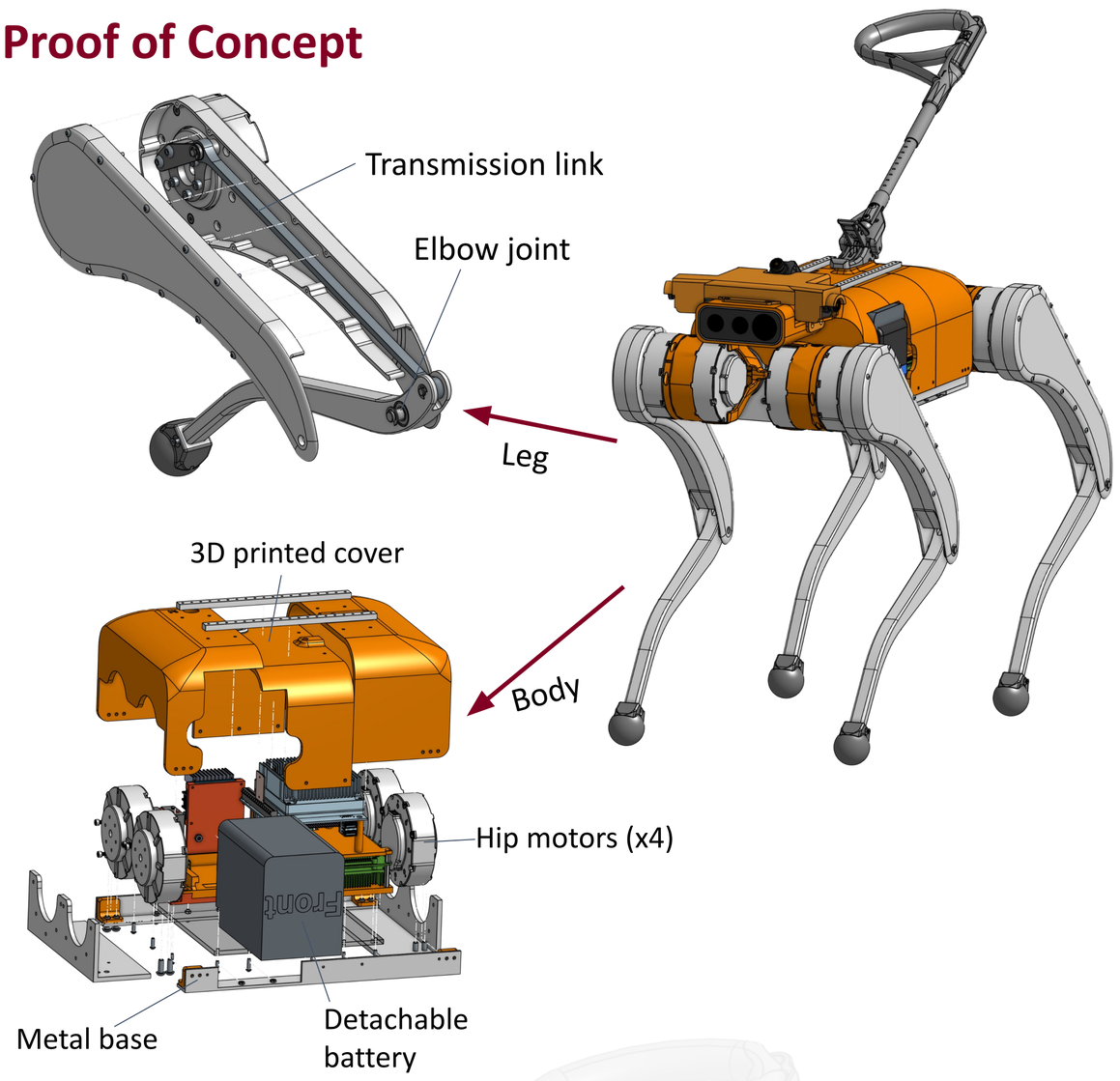
Commercially Available Quadrupeds
- Large scale: Can climb stairs but too big
- Small scale: Can't climb stairs but small enough

Selected Design Solution



Last Semester | This Semester

Proof of Concept



Specifications

	Ideal	Marginal
Rise/go [m/m]	0.20/0.25	0.18/0.28
Mass [kg]	≤ 21.5	≤ 25
Storage Volume [m^3]	< 55.88 x 35.56 x 22.86 cm^3	55.88 x 35.56 x 22.86 cm^3

Engineering Standards: ISO 13482, ISO 286, ADA § 504, ASTM B308/B308M-20, ASTM A1018/A1018M-18

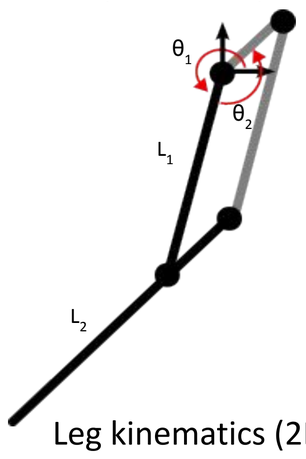
Engineering Analysis

Inverse Dynamics

$$\tau = J^{\mathrm{T}}(\theta) f_{\mathrm{tip}}$$

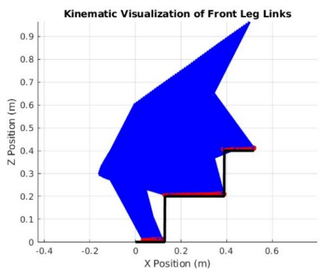
Maps motor torques to forces on foot

$\tau \in \mathbb{R}^2$
$J \in \mathbb{R}^{2\times 2}$
$f_{tip} \in \mathbb{R}^2$



Leg kinematics (2D)

Kinematics to Find Link Lengths:



Obtain % coverage

Trial & error

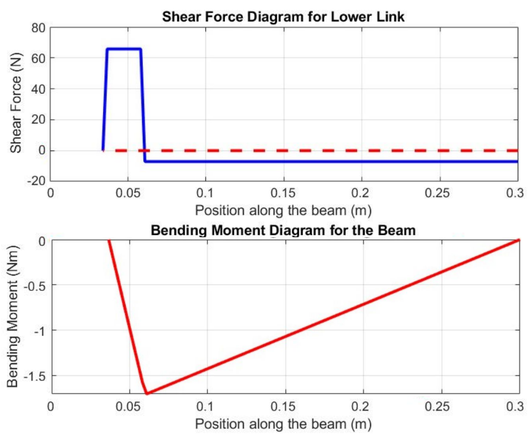
Leg Type	Link Length
Upper link	300 mm
Lower link	330 mm

Link lengths (Maximize % coverage)

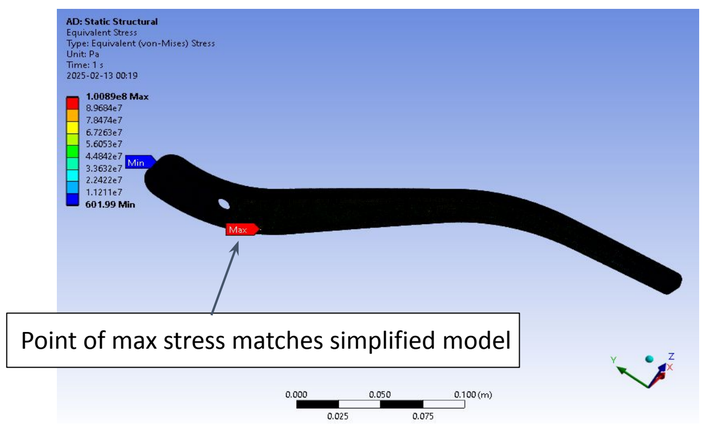
Strength of Linkage:

$$FOS = \frac{\sigma_{yield}}{\sigma_{max}} \qquad \sigma_{max} = \frac{(M_{max} \times c)}{I_z}, \qquad S = \frac{I_z}{c} = \frac{M_{max}}{\sigma_{max}}.$$

*Treated Link as simple beam



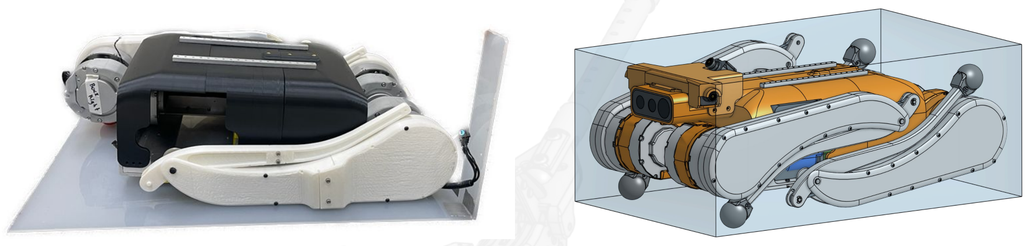
Shear bending moment diagram of simplified model



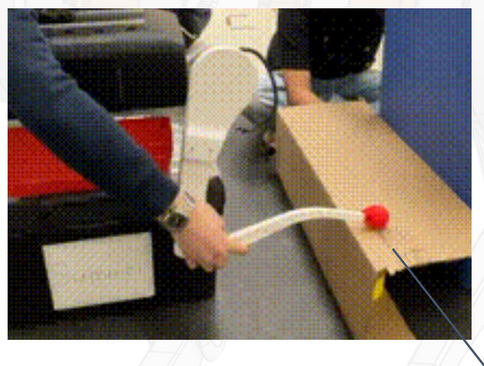
Finite Element Analysis of detailed model

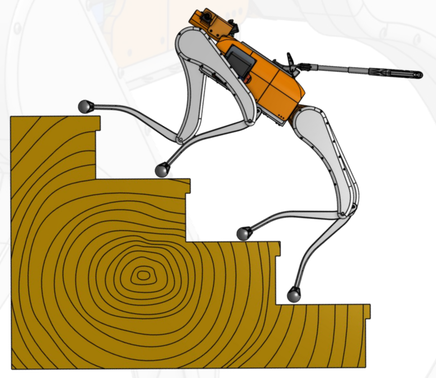
Performance Evaluation

- Storability
  - Final Volume: **53.97 x 28.58 x 17.15 cm^3**



- Portability
  - Final Weight: **19.08 kg**
- Stair Climbing





Successfully reaches the staircase

Recommendations

- Build final design with metal legs when delivered
- Continue researching perception, controller design and path planning

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